

Maize-based diversification

options for rice-wheat cropping system

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Indian agriculture is facing the triple challenge of doubling the food production by 2030, restoration of degraded soils and alleviating the poverty. Crop diversification can help to increase the income of small landholder farmers besides conservation of natural resources. Adoption of rice-wheat cropping system in Indo-Gangetic Plains of north-western India, which is water-capital-energy-intensive, causes serious threat to the agricultural sustainability. Diversification of rice-wheat (RW) system with maize-based cropping systems could help to enhance the system productivity, sustain soil health and save irrigation water and labour costs. Inclusion of short duration legume crops after cereals/oilseed crops have synergistic effect on system productivity and water-use. Adoption of different maize-based cropping systems i.e maize-wheat-green manure, maize-potato-summer moong, maize-potato-onion can help in increasing the farmers' income and alleviating the soil health degradation. Promotion of such cropping systems; however, will require better policy support in terms of MSP, assured marketing and trade opportunities.

Keywords: Cropping system, Diversification, Maize, Pulses, Rice-wheat

RICE-wheat is elementary to employment, income and livelihood for millions of people in the Indo-Gangetic Plains (IGP) of India occupying 10.5 m ha. Although rice-wheat is the most overwhelming crop sequence of Indo-Gangetic Plains, yet its continuous rehearsing has brought about a number of ecological and other second generation problems such as low input-use efficiency, nutrient deficiencies, decreasing partial factor productivity, environmental deterioration etc besides insect-pests, disease and weed problems entailing use of pesticides. Multiple resistant weeds in wheat in North-West India are posing a serious threat to the sustainable weed management and seriously impacting cost of wheat production. These impending elements have given thrust to pursuit for alternative crops and cropping systems, which are productive, environment friendly and efficient in utilizing natural resources. Maize

holds an important position in Indian agriculture and is the third major crop after rice and wheat. It has highest genetic yield potential and can be grown under different soil and climatic conditions making it as the miracle crop. Increasing utilization of maize for animal and poultry feed, the interest of consumers for nutritionally enriched products for human consumption, and rising demand for industrial alcohol and other uses are the main thrusts behind increased importance in India. To take care of rising food demand, a quantum jump in maize production is the need of the hour. The development of single cross high-yielding maize hybrids has provided options for RW cropping system diversification. In the North-Western Indo-Gangetic Plains, maize is usually grown in rotation with chickpea, wheat, potato, mustard and winter maize. The other drivers for substituting rice with crops like maize in rice-wheat cropping system include expanding maize

demand for poultry feed; tightening world export-import market and its enhanced productivity and profitability compared to the other crops.

Maize-based diversification options

Maize has wider compliance and compatibility under different soil and climatic conditions; and cultivated as major crop in sequential cropping systems under various agro-climatic zones of country. Location specific research identified several cropping systems which have better productivity with same or even less use of water than rice-wheat system in different agro-climatic zones of IGPs. For example, at Ludhiana, maize-potato-onion, maize-potato-mungbean systems gave rice equivalent yield of 31.98 and 22.86 t/ha, respectively compared to 12.87 t/ha in case of rice-wheat system (Table 2). Promotion of such cropping systems; however, will require better policy support in

terms of MSP, assured marketing and trade opportunities. Some of the water efficient productive cropping systems are listed in Table 1. Maize-wheat ranks first among these cropping systems occupying 1.8 m ha area, contributing 3% in the national food basket and ranks third most important after rice-wheat and rice-rice cropping systems. All India coordinated Research Project on Cropping Systems revealed that use of natural resources enhanced with maize-based cropping systems, as compared to rice-wheat and other rice-based cropping systems, and have 100 to 200% higher water-use efficiency at different locations. Higher equivalent yield, gross and net returns was obtained with maize based cropping systems as compared to traditional rice-wheat cropping system (RWCS). Maize-vegetable pea-spring maize and maize-potato-spring maize produced nearly 128% and maize-potato-spring maize results 78% higher maize equivalent yield than RWCS (Table 3). So, inclusion of pulses, oilseeds and vegetables in the system is more beneficial than cereals after cereals, and such inclusion in a sequence changes the economics of the crop sequences. To solve the second generation problems and enhance the farmers' income, it is need of hour to diversify the traditional rice-wheat cropping system. Some of the following of the maize-based alternative can be adopted for diversification.

Maize-wheat-green manure

After harvesting of wheat, broadcasts seed of a green manure crop in the last week of April and incorporating after 45-50 days and allow it to decompose for 10-12 days. In such conditions, no more application of organic manure is required for maize in green manured field.

Maize-potato-wheat

In this cropping system, a short duration maize variety can be sown in mid-June so that field can be vacated by mid-September. After harvesting of early maturing variety of potato planted in end of

September, sowing of late variety wheat can be done.

Maize-potato-summer moong

In *kharif* season, to vacate the field for timely sowing of potato in second fortnight of September, maize can be sown in mid-June. After maize harvesting, potato can be raised with the recommended dose of fertilizers. No need to apply the fertilizers to mung bean after the application of recommended dose of fertilizers in potato.

Maize-potato-onion

This system is more remunerative with higher productivity with substantial saving of water as compared to conventional rice-wheat system. For higher yield realization of crops, maize can be planted in mid-June. After harvesting of maize, potato can be sown in first week of October and onion can be transplanted up to 15th January after potato harvesting. This system also helps in improving soil fertility in terms of OC, available N, P and K.

Maize-potato-mentha

Sowing of maize can be done in mid-June to vacate the field in the second fortnight of September and potato can be planted in first week of October and mentha in the second fortnight of January. This system gives higher profit as compared to rice-wheat cropping system.

Maize-gobhi sarson-summer moong

Higher yield can be obtained from this system compared to maize-wheat or rice-wheat systems. After harvesting of maize sown in first fortnight of June, sowing of gobhi sarson can be done from October 10-30. The summer moong can be sown directly with zero-till drill after applying pre-sowing irrigation in the second fortnight of March or first fortnight of April.

Maize-vegetable pea/potato-spring maize

System productivity and economic returns are higher with these alternate cropping systems as compared to rice-wheat system. Maize can be sown in the first fortnight of June. After harvesting of maize, pea or potato can be sown in first fortnight of October and spring maize in first fortnight of February. For higher yield and to save water, preferably grow spring maize under drip irrigation system.

Speciality maize

Baby corn and sweet corn are two major speciality corn for cultivation in peri-urban areas to increase the net profit and improve the livelihood security of people. Cultivation of these also leads to livestock promotion by catering the requirement of green fodder. Consumption of sweet corn and baby corn is also increasing in developing countries. Higher demand of these



Maize-vegetable pea-spring maize, maize-potato-spring maize, rice-wheat, maize-toria-spring maize based cropping systems

Table 1. Maize-based cropping systems in different agro-climatic zones of India

Agro-climatic region	Irrigated	Rainfed
Lower Gangetic Plain region	Autumn rice-maize	Rice-maize
	Jute-rice-maize	
Middle Gangetic Plain region	Maize-early potato-wheat-mungbean	Maize-wheat
	Maize-wheat	
	Maize-wheat-mungbean	
	Maize-wheat-urdbean	
	Maize-sugarcane-mungbean	
Upper Gangetic Plain region	Maize-wheat	Maize-wheat
	Maize-wheat-mungbean	Maize-barley
	Maize-potato-wheat	Maize-safflower
	Maize-potato-sunflower	
	Maize-potato-onion	
	Maize-potato-sugarcane-ratoon	
Trans Gangetic Plain region	Maize-wheat	Maize-wheat
	Maize-wheat-mungbean	
	Maize-potato-wheat	
	Maize-potato-sunflower	
	Maize-potato-onion	
	Mungbean-maize-toria-wheat	
	Maize-potato-mungbean	
	Maize-potato-spring maize	
	Maize-vegetable pea-spring maize	

Table 2. Rice equivalent yield, net returns and water productivity of different cropping systems

Cropping system	Potential yield (t/ha)	Net return (₹ Lakh/ha)	Water productivity (kg grain/m ³ irrigation water)
Rice-wheat	13.33	1.28	0.59
Maize-wheat-mungbean	14.64	1.62	2.07
Maize-mustard-mungbean	14.84	1.80	7.00
Maize-potato-watermelon	57.0	2.50	High

Source: Rakshit *et al.* (2021). Diversification of cropping systems in Punjab and Haryana through cultivation of maize, pulses and oilseeds. Policy paper. ICAR-Indian Institute of Maize Research, Ludhiana, p. 37.

Table 3. Maize equivalent yield, gross and net returns and productivity efficiency of different cropping systems

Cropping system	Maize equivalent yield (t/ha)	Gross return (₹/ha)	Net return (₹/ha)	Production efficiency (kg/ha/day)
Rice-wheat	12.35	182995	110393	33.9
Maize-vegetable pea-spring maize	28.15	395745	238987	77.1
Maize-toria-spring maize	13.27	206717	105695	36.4
Maize-potato-spring maize	21.96	318591	149194	60.2

Source: Adopted and Modified from Todar Mal *et al.* (2018). Productivity and economics of different cropping systems in relation to tillage, mulching and fertilizer management practices in north-western Indo-Gangetic Plains of India. *Indian Journal of Agricultural Sciences* **88**(2): 216–21.

corn in developed countries provides opportunity for export. Baby corn is highly nutritious and rich in calcium, phosphorus, vitamins and other nutrients. Integration of baby corn cultivation along with dairy

farm can provides more benefits as only 13 to 20% of fresh ear weight is used as human food and remaining husk and silk and stalk can be used as green fodder for ruminants. Overall cultivation of speciality

corn provides higher income, more cropping intensity, increase in milk and meat production, better value addition and more employment generation. Their global spread, increasing demand and premium price make them an attractive option for the farmers in many foreign countries including India. Speciality corns are amenable to numerous options pertaining to harvest time and various economical products.

The quality protein maize (QPM) productivity is similar to normal maize, however, the biological value of QPM is almost double as compared to normal maize and more than rice and wheat. True protein digestibility of QPM is similar to milk, which helps in reducing feed requirement. Per unit protein production expenditure in QPM is much lower as compared to animal protein, so it can be used as nutritional food for ill-nourished population especially in tribal and hilly regions. Besides this, QPM can be used as nutritionally superior food for pregnant and lactating women, adolescent and old age population of the country. QPM also provides quality feed to poultry industry. Thus QPM can ensure food and nutritional security in India.

Resource conservation techniques in maize-based cropping systems

The key to achieve the optimum plant stand and higher crop productivity is crop establishment. Interaction between seed, soil moisture, seedling depth, method of sowing etc. determines the crop establishment. Traditionally, crops are grown mostly after tilling the field either in row or by random broadcasting. These traditional methods of sowing have limitations such as uneven plant stand, improper plant geometry resulting in low input-use efficiency and low crop productivity. Intensive tillage contributes to nearly 30% of the cost of production resulting in lower economic returns, decrease in soil organic matter and biodiversity. Various resource conservation technologies like zero tillage, raised bed planting etc came in practice for various maize-based cropping

systems. Some of RCTs for maize sowing are:

Zero-till planting: Maize can be grown under no-till condition with saving in diesel and time resulting in reduced cost of cultivation, reduced environmental pollution, higher farm productivity and better resource use efficiency. It is necessary to ensure good soil moisture at sowing for better germination and good early crop stand.

Raised bed/Ridge planting: As maize is sensitive to excess as well as water deficient conditions, planting maize on raised beds is considered best planting method. Sowing can be done on southern side of east-west ridges/beds. Under excess/ water logging conditions, furrow act as drainage channels. To exploit full potential of bed planting, sowing can be done without any preparatory tillage on permanent beds. Raised beds/ ridges can save 20-30% irrigation water and give higher crop productivity.

Trench method: For ease of irrigation during dry and hot weather conditions, maize can also be sown in trenches at 60 × 20 cm

spacing. In addition, it resists lodging and gives higher productivity than flat sowing.

Need based nitrogen management in maize using LCC: Apply 30 kg N/ha as basal dose. After 21 days of sowing, start matching the colour of fully exposed leaf from top at 10 days interval. Whenever LCC shade less is than 5, apply 28 kg N/ha. If LCC ≥ 5 , no need to apply nitrogen. Use of LCC can be discontinued after initiation of silking as no more nitrogen is needed.

Drip irrigation: Recent studies have shown that micro-irrigation gives the higher yield than conventional method of irrigation. Maize, sunflower, gram, green gram and other grain crops can be grown by using micro-irrigation systems. Experiments revealed that drip irrigation can save up to 45% irrigation water besides enhancing water-use efficiency, higher net returns under maize based intensive cropping systems.

Weed control: Uniform spray of 500-600 g/acre Atrataf/ Atragold/ Masstaf/ Atari (atrazine) within 10

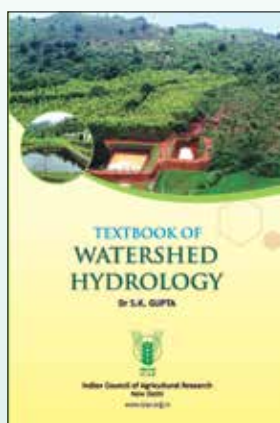
days after sowing in 200 l/acre water followed by one hoeing at 30 days after sowing gives effective control of weeds. Alternatively, spray 115 ml per acre Laudis 420 SC (tembotrione) in 150 litres of water at 20 days after sowing provides effective control of mixed weed flora.

SUMMARY

Green revolution shifted the area of rice-wheat cropping system in Punjab and Haryana from 37% and 20% in 1966 to nearly 84% and 61% in 2018, respectively resulting in over exploitation of ground water, increased energy demand, depletion of soil fertility and burning of rice residues. Based on the demand and economic returns, maize-based cropping systems can replace the rice and wheat crops by improving the soil fertility with additional income. Adoption of resource conservation techniques in maize-based cropping systems can further enhance the water productivity and net income of the farmers.

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